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BODY COMPOSITION AND WORK PERFORMANCE OF CADETS AT THE UNITED STATES MILITARY ACADEMY, WEST POINT, NEW YORK

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LETTERMAN ARMY INSTITUTE OF RESEARCH
PRESIDIO OF SAN FRANCISCO, CALIFORNIA 94129

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Body Composition and Work Performance of Cadets at the United States Military Academy, West Point, New York--Fults et al

Human Subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Reg 50-25 on the use of volunteers in research.

John W Marshall Jr 14 June 82
(Signature and date)

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A study was conducted to evaluate the cadet weight control program at the United States Military Academy, West Point, New York. During the spring academic quarter of 1979, eighty-six cadets at the Academy were enrolled in the weight control program. This represented 2% of the male and 17% of female cadets enrolled. This report is concerned with the body composition and work performance aspects of the study. The study was conducted in two phases. Phase I, conducted during the spring quarter

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of 1979, evaluated the procedures used to estimate the body composition of the cadets. Phase II, conducted in the fall of 1979, studied the body composition and the work performance of the cadets.

In Phase I there were no significant differences in height, weight, skinfold thickness, or circumference values with respect to which entrance class the cadets were in. The recognized sex differences were observed; namely, males are generally relatively larger than females, but females are relatively fatter. However, subscapula and suprailiac skinfold values and thigh circumference measurements did not differentiate males from females. Comparisons of methods used by LAIR and USMA for the determination of the percent of body fat were highly favorable. Although the body fat estimate by the USMA method was significantly lower by 0.4 percent of body fat, this small difference in percent of body fat is of no practical significance. Hence, the procedures used at USMA to estimate the percent of body fat appear reliable.

The observations noted in phase I were found again six months later in phase II. However, a uniform weight gain that averaged 1.2 kilogram per cadet occurred during this period. In addition, subscapular, abdominal, and thigh skinfold values fell between the phases. The increase in weight could not be accounted for by an increase in percent of body fat. The male cadets exceeded the female cadets in work performance. Oxygen uptake (V_{O_2}max) was greater for the males either on an average individual basis or per kilogram of body weight. No differences in performance were observed between the four academic classes of male or female cadets. The data were inadequate to identifiy an optimum body composition for the cadets.

ABSTRACT

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TABLE OF CONTENTS

A study of body composition and work performance of cadets at the United States Military Academy, West Point, New York (USMA) was conducted at the request of the USMA Department of Physical Education (DPE)(1). Results of the study are the subject of this report.

During the spring academic quarter of 1979, eighty-six cadets (45 male, 41 female) were enrolled in the cadet weight control program (CWCP) administrated by DPE (Appendix A). These numbers represented 2% of the male and 17% of the female population in the United States Corps of Cadets (USCC) at that time. In addition, 38 other cadets (31 male, 7 female) had been enrolled and later released from the CWCP during the 1978-1979 academic year.

This situation concerned the USMA command staff because a policy was being formulated for separating obese cadets from the academy. With the cost of education near $100,000 per cadet, a substantial financial impact would result by separating even a few cadets. Because obesity is a potentially correctable problem, the CWCP was instituted and this study as well as addenda were implemented to enhance its effectiveness.

The purpose of this study was to evaluate the CWCP and formulate recommendations for improvement. Within the context of cadet life at the USMA the number of cadets participating in the CWCP was considered to be unacceptably high and indicative of a possibly general weight control problem. Three possible reasons were indentified as explanations for the size of CWCP population. First, the cadets may indeed be overfat due to food consumption in excess of daily energy requirements. Second, the CWCP method for measuring body fat may yield incorrect results and indentify cadets as being overfat when they are not. Third, the CWCP criterion for selecting overfat cadets may be incorrect or inappropriate. Identification of any of these reasons was within the scope of this study.

Due to limitations imposed by availability of manpower, equipment, and cadet time, the study was conducted in two phases. Phase I was accomplished in the spring quarter of 1979; Phase II in the fall of 1979. Phase I was a study of body composition intended to examine the first and second considerations listed above. Phase II studied body composition and work performance in order to evaluate the third consideration as well as help indentify body composition trends that may occur during the academic year.

EXPERIMENTAL DESIGN

It was estimated that 25 males and 25 females from each class, plus 25 males and 25 females from the CWCP, would provide adequate statistical power for the multifactor repeated measures design appropriate to this study. Thus the prospective populations were 225 subjects for Phase I (there were no females in the class of 1979) and 250 subjects for Phase II. The experimentally accessible population for Phase I was 240; however, complete data were obtained only on 221. In Phase II, complete data were obtained from 138 subjects, of which 58 had also completed Phase I of the study. As shown in Table 1, the distribution was not 25 subjects per cell as desired.

The non-uniform distribution of study subjects was due to the voluntary subject participation and the time constraints built into a field study. Collecting complete data required 5 to 7 hours from each subject. This time was divided into several sessions that the subjects were free to schedule according to their individual needs. It was important that interference with cadet academic work be avoided. Thus, a number of subjects withdrew from the study and appointments were frequently cancelled by the subjects too late for the time slot to be reassigned. The investigation team was limited to 5 weeks (Phase I) and 7 weeks (Phase II) on site and eventually time expired before all cancellations could be rescheduled or all dropouts could be replaced.

Participation was also limited by another important factor. Only 9 cadets from the CWCP volunteered. Although they were assured of the strict confidentiality of the data, cadets already under scrutiny in the CWCP were reluctant to call further attention to themselves by participation in this study. There were likewise cadets in the general population who, to avoid jeopardy under the CWCP, refused to volunteer This was an inherent disadvantage to studying a criterion for dismissal from the academy.

Since the analysis program, BMDP2V (2), accomodates unequal group sizes, there were no problems with data analysis. However, the small number of vounteers from CWCP precluded any comparisons between cadets in CWCP and the general population. Thus, data from all cadets were pooled and the CWCP factor was removed from the design.

Data from Phase I were acquired in order to evaluate: (a) the validity and accuracy of CWCP body fat estimates; (b) measure the actual body fatness of the USCC population, and (c) identify trends in body fatness related to sex or tenure at the USMA. The following hypotheses (stated in null form) were among those tested:

I-1. There is no difference between body fat estimates made according to the CWCP protocol and estimates made using generally accepted (and presumably more accurate) laboratory methods.

I-2. There is no difference in relative body fatness between male and female cadets.

I-3. There are no differences in relative body fatness among classes.

I-4. There is no interaction between the effects of sex or class on reactive body fatness.

I-5. There is no interaction among class, sex, and methodology on body fatness measurements.

Data from Phase II were acquired for the purpose of evaluating changes in body composition over a 6-month period as well as work performance and energy expenditure of cadets. In addition, a first order attempt was made to identify objectively the optimum body composition for cadets (an admittedly optimistic undertaking). The following null hypotheses were among those tested:

II-1. There is no difference in work performance between male and female cadets.

II-2. There are no differences in work performance among classes.

II-3. There is no class by sex interaction affecting work performance.

Data from both phases were used to test the following hypotheses.

III-1. There is no difference in relative body fatness between Phase I and Phase II.

III-2. There are no interactions among class, sex, and phase affecting relative body fatness.

Other hypotheses were tested in order to facilitate interpretation of the results. They are described at the appropriate points in the discussion.

METHODS

During Phase I, body composition measurements were obtained before the subjects ate breakfast (between 0430 hrs and 0630 hrs) on weekdays. These measurements included body volume, weight, height, 14 skinfold thicknesses and 7 circumferences. Body volume and weight were measured on subjects dressed in nylon swimsuits. The weight and volume of these suits were determined to be within the error of reproducibility of the measurements and therefore introduced negligible error into the results.

The 14 skinfolds were measured bilaterally at seven sites: triceps (TCR, TCL); subscapula (SSR, SSL); biceps (BCR, BCL); supra-iliac (SIR, SIL); lateral abdomen (LAR, LAL); abdomen (ABR, ABL); and thigh (THR, THL). The site definitions for TCR, TCL, SSR, SSL, BCR, BCL, SIR, and SIL were taken from Durnin and Wommersley (3). The LAR and LAL measurements were devised by DPE for use in the CWCP and defined as the thickness of a vertical skinfold made at the intersection of a horizontal line across the abdomen at the level of the iliac crest and a vertical line intersecting the anterior process of the pelvis. The ABR and ABL skinfolds were defined as the thickness of horizontal skinfolds measured immediately lateral to the umbilicus. The THR and THL measurements were vertical skinfolds on the anterior thigh midway between the condiles of the femur.

The seven circumferences were measured around the neck (NK), shoulders (SH), chest (CH), abdomen (AB), buttocks (BU), and thigh (bilaterally; TR, TL). The NK measurement was taken just inferior to the larynx. The SH was measured over the deltoids. The CH was taken at the end of a passive expiration at the level of the xiphoid process. The AB was measured over the umbilicus. The BU was measured at the level of the top of the femur. Circumferences TR and TL were measured over the THR and THL skinfold sites.

Skinfolds were measured to the nearest 0.5 mm with a Lange caliper (4) and the average of three trials was recorded. Weight was recorded to the nearest 10 g from a triple beam balance (5). Height was recorded to the nearest millimeter read from a free standing anthropometer (6). Circumferences were measured to the nearest millimeter with a constant tension steel tape measure (7).

Body volume was measured in a human body volumeter using the method of Allen et al. (8) the method routinely used at the Letterman Army Institute of Research. The water level in the volumeter was recorded to the nearest 0.25 mm prior to the subject's entry. After entering the tank, each subject performed a forced expiration

to residual volume and submerged for about 10 seconds. This procedure was repeated until successive trials agreed within 1 mm on the water level scale. The smallest volume obtained was recorded.

Residual volume (RV) was measured while the subject stood submerged to the neck in the volumeter. While wearing a nose clip, the subjects performed a forced expiration to residual volume, inspired 200 ml of helium from a rubber aliquot bag fitted with a mouthpiece, then repeatedly respired into the bag to mix the helium and residual gas thoroughly. Upon the final expiration, the bag was clamped and the helium concentration (F_{EHe}) measured with a catharometer (9). The residual volume (RV) was calculated from the helium dilution equation: $RV = 200(1-F_{EHe})/F_{EHe}$ ml. This method was developed for speed and convenience of use within the confines of the volumeter. Its validity will be reported elsewhere.

In addition to the early morning body composition measurements, whole body burdens of potassium-40 (^{40}K) were determined by gamma radiation counting. The ^{40}K data were obtained using the LAIR shadow shield whole body counter (10). For this test, subjects wore duty uniforms and the half-hour scan was done sometime between 0700 and 2200 hrs.

During the procedure, the subjects were clothed and lying supine on a padded sled. The sled, under mechanical control, was slowly moved past a thallium-activated sodium-iodide crystal. The crystal, sensitive to the natural gamma radiation emitted by the body, is connected to a gamma spectrum analyzer. Data from a 30 minute scan were transferred from the analyzer to a minicomputer (MCII) (11), which quantitated the radioactivity associated with the 1.46 MeV ^{40}K photopeak. From this the amount of potassium in the body was computed and from that the fat-free body mass derived (12).

Data acquired during Phase II included the anthropometry described above with the exception of circumferences. Work performance abilities were determined from a graded exercise test (GXT). Anthropometry measurements were made at the same testing session. The measurements, which required one-hour sessions, were performed between 0800 and 1700 hr on weekdays.

In the GXT protocol, the subjects walked on a motor driven treadmill (13) at a quick but comfortable pace (3.0 to 4.0 mph). At two-minute intervals, the elevation was raised 2% until the subjects voluntarily terminated the test. Throughout the test the blood pressure (BP) was monitored with an electronic sphygmomanometer (14).

The electrocardiogram (ECG) was periodically recorded and monitored on a 3-channel recorder (15) and continuously displayed on a 2-channel CRT (16). A physician was present during all GXT measurements.

Breath-by-breath oxygen consumption (V_{O_2}) was measured with a respiratory mass spectrometer (RMS) (17). During the last minute at each grade, the breath by breath V_{O_2} values were integrated and a 10 beat average heart rate was measured from the ECG recording. The data were transferred to a MCII minicomputer where maximal oxygen uptake ($V_{O_{2max}}$) as well as the relationship of V_{O_2} to heart rate from rest to maximum were computed.

For both phases of this study, data reduction, file preparation, and graphics were done on the MCII and an Eclipse C/330 minicomputer (18). Statistical analysis and archival were performed using the BMDP package (2) on a CDC 7600 computer (19).

RESULTS AND DISCUSSION

The distribution of subjects within factors of the experimental design is shown in Table 1. With the exception of the weight control groups, the participation goal of 25 subjects per cell was essentially met in phase I. There were only 17 females representing the class of 1981, however, in light of the excess numbers in other cells the power of the design was adequate.

Participation in phase II was not up to expectation. Females in particular and the freshman class in general were reluctant to volunteer. The reason for the lack of interest on the part of the females is not clear. The freshman class had only been attending classes for two months at the start of this phase of the study. They seemed to feel that the time commitment required to participate in the study would interfere with their academic work. This would apparently be the consensus of any freshman class early in the academic year. In contrast, the freshman class showed the highest participation in phase I, which was conducted in late spring. One might conclude that 6 to 8 months after matriculation they have adjusted to the academic environment and are ready for extra-curricular activities.

The data acquired in phase I are shown in Tables 2 through 6. Height and weight data are found in Table 2. The skinfold values are presented in Table 3 and circumferences in Table 4. Body fat determination comprises Table 5, while comparison of measurements made by different investigators are shown in Table 6.

The data in Tables 2 and 4 were analyzed as a 2x4 (sex by class) factor design using multifactor analysis of variance program BMDP2V (2). The following results were obtained from the analysis:

1. There were no significant differences among classes for any of the variables measured.
2. There were no significant interactions between sex and class factors.
3. In general the effect of sex on any parameter was significant at the <0.05 level.

Exceptions to the sex effect stated above are noted in the tables. The obvious sex differences were confirmed; that is, males are generally relatively larger but females are relatively fatter. It is interesting to note that the subscapula (SSL,SSR) and suprailiac (SILR,SIR) skinfold values and the thigh (TR) circumference values cannot be used to differentiate between males and females.

In order to compare methodology, the data in Table 5 were analyzed by a 2x4x4 (sex by class by method) multifactor repeated measured design using the BMDP2V program. The analysis produced the following results:

4. There were no significant differences in percent body fat among classes.
5. The effect of sex on percent body fat was significant at the $p<0.05$ level.
6. The effect of methodology on the percent body fat measurement was significant at the $p<0.05$ level.
7. All interactions among factors were significant at the $p<0.05$ level.

Based upon these analysis, the following statement about the hypothesis for phase I are appropriate:

Hypothesis I-1: (no methodology effect) may be rejected at the $p<0.05$ level.
Hypothesis I-2: (no sex effect) may be rejected at the $p<0.05$ level.
Hypothesis I-3: (no class) effect is tenable.
Hypothesis I-4: (no class by sex interaction) is tenable.
Hypothesis I-5: (no class by sex by methodology interaction) may be rejected at the $p<0.05$ level.

In order to test the influence of investigator technique on the anthropometry method in use at West Point, measurements were made on a subset of the subjects by the DPE instructors who usually perform fat estimates for the CWCP. The measurements on subjects in this subset made by the DPE instructor (USMA) were pooled, and compared with the LAIR measurements. The data are shown in Table 6.

The data were analyzed as a 2x4x2 (sex by class by investigator) multifactor repeated measures of analysis of variance (ANOVA). The differences between investigators for triceps and biceps measurements were not significant. The DPE subscapular measurement (SWP) was significantly lower ($p<.001$) by 0.75 mm. The DPE lateral abdominal measurements was significantly higher ($p<.038$) by 0.13 mm. The resulting relative body fat estimate by DPE was significantly lower ($p<.003$) by 0.4 % of body fat.

Although these differences are statistically significant (attesting to the statistical power of the experimental designs), they are not meaningful because they are quite small in the practical sense. A difference of only 0.4% body fat estimates made independently by three individuals indicates that the anthropometric measurement can be made reliably by a trained person. A regression analysis was performed (using BM DP6Q) on the investigation factor. The regression equation of $y = 0.997x + 0.404$ and the correlation coefficient approaching unity also indicate the reliability of measurements made by different individuals. The intercept (0.4) corroborates the lower DPE estimate identified by the ANOVA. It is worthwhile to emphasize that a difference of 0.4 in percent of body fat is of no practical significance.

Data acquired during phase II of this study are shown in Tables 7 through 10. Height and weight values are given in Table 7. Skinfold thicknesses values are found in Table 8. The anthropometric fat estimates are shown in Table 9 and the results of the GXT are provided in Table 10.

These data were analyzed as a 2x4 (sex by class) design using BMDP2V. The following results were obtained:

1. There were no significant differences among classes for any variable.
2. There are no significant class by sex interactions for any variable.
3. The males and females were significantly different for all variables, except for the subscapular, lateral abdominal, and abdominal skinfolds measurements.

The obvious trends due to sex were again noted. The null hypotheses about phase II may now be evaluated.

Hypothesis II-1: (no sex difference in performance) may be rejected at the $\rho = 0.002$ level.
Hypothesis II-2: (no class differences in the performance) is tenable.
Hypothesis II-3: (no class by sex interaction) is tenable.

The data from subjects completing both phase I and phase II are presented in Tables 11 through 13. The height and weight data are found in Table 11. Table 12 shows the skinfold data, and Table 13 shows the relative body fat data. When analyzed in a 2x4x2 (sex by class by phase) repeated measures design using the BMDP2V program, the following results were obtained:

1. There were no significant differences among classes for any variable.
2. The few signficant differences under the sex factor showed the obvious trends.
3. There was a uniform weight gain averaging 1.2 kg from phase I to phase II
4. A phase effect was noted by changes in the subscapular abdominal and thigh skinfold values.

The last of the null hypotheses in this study may now be evaluated:

Hypothesis III-1: (no change in percent of body fat) is tenable.
Hypothesis III-2: (no class, sex, phase interaction) is tenable.

CONCLUSIONS

In phase I there were no significant differences in height, weight, skinfold thickness, or circumference values with respect to which entrance class the cadets were in. The recognized sex differences were observed; namely, males are generally relatively larger than females, but females are relatively fatter. However, subscapula and suprailiac skinfold values and thigh circumference measurements could not differentiate between males and females.

Comparison of methods used by LAIR and USMA for the determination of the percent of body fat were highly favorable. Although the body fat estimate by the USMA method was significantly lower by 0.4 percent of body fat, this small difference in percent of body fat is of no practical significance. Hence, the procedures used at USMA to estimate the percent of body fat appear reliable.

The observations noted in phase I were found again six months later in phase II. However, a uniform weight gain that averaged 1.2 kilogram per cadet occurred during this period. In addition, subscapula, abdominal, and thigh skinfold values fell between the phases. The increase in weight could not be accounted for by an increase in percent of body fat.

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The data were too inadequate to identify an optimum body composition for the cadets.

RECOMMENDATION

None.

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Cadets Weight Control Program

APPENDIX A

THE UNITED STATES CORPS OF CADETS

WEIGHT CONTROL PROGRAM

RESPONSIBILITY:

The Director, Department of Physical Education (DPE), is responsible for the administration of the USCC Weight Control Program.

IDENTIFICATION:

Cadets will undergo biannual height/weight surveys, typically held in conjunction with regularly scheduled DPE testing. Those cadets found to exceed, or be within 2% of exceeding, the maximum body weights in AR 600-9 will be required to report to DPE for a percent body fat measurement.

Additionally, cadets are required to report to DPE for a body fat measurement when:

a. Volunteering for the program.

b. Directed by an officer or another cadet in the chain of command.

PERCENT BODY FAT CALCULATION:

Percent body fat will be calculated for cadets using skinfold techniques and mathematical formulas, a relatively simple and accurate method. The normal error encountered by such measurements is taken into account in developing standards. The skinfold technique accounts for body build, muscular development, muscle tone, and bone structure. AR 600-9, Paragraph 3-4, indicates that these body parameters should be included in obesity determination.

Once the percentage of body fat is calculated, cadets will be categorized as follows:

PERCENT BODY FAT

CATEGORY	MALE (%)	FEMALE (%)	REMARKS
V	0-5	0-8	Very low, caution
IV	5.1-10	8.1-17	Excellent
III	10.1-15	17.1-22	Acceptable
II	15.1-16	22.1-23	High, bi-weekly weigh-ins required.
I	over 16.1	over 23.1	Mandatory Weight Control program.

WEIGHT CONTROL PROGRAM

Cadets who are in Categories I or II are required to report to DPE Weight Control Clinic every 7-14 days to be weighed.

Cadets in Category I will be allowed a period of time to lose adipose tissue (fat) in order to achieve Category II or a higher category. Time allowed to lose fat will be equal to one week for every 0.5% body fat they exceed the body fat limits of Category II; however, the time period will not be less than two weeks. For example, a male cadet may weigh 200 pounds of which 19% is fat. Since his percent body fat is 3% over the 16% Category II limit, he is allowed 6 weeks to lose that 3% body fat. In this case, the 3% body fat equals 6 pounds of adipose tissue.

If a cadet has not attained the appropriate level of body fat at the end of the prescribed time period, there are two possible courses of action. At the discretion of the Director, DPE, the cadet will be recommended for dismissal, or will be granted a time extension to reach the required goal. The extension, if granted, will be no longer than one-half the originally prescribed time period. For example, the cadet described above is found to have 18% body fat at the end of the 6 weeks. He could be granted a maximum extension of 3 weeks to reach the Category II level of 16% body fat. Should the cadet still fail to reach a Category II level during the extension, the cadet may be recommended for dismissal.

Cadets who fall into Category II, or higher, and who regress into Category I two (2) or more times during any one Academic Year, may be recommended for administrative dismissal. For example, in September a female cadet may weigh 140 pounds with 24.5% body fat. she is granted 3 weeks to make the 23% Category II limit. At the end of the 3 week period she is found to have 22.5% body fat which is within the Category II limit. The cadet is then required to weigh-in at DPE bi-weekly. A weight gain is discovered in November, and a new resultant percent body fat measurement shows her to have 23.5% body fat. She is then allowed another period of two weeks to attain the Category II level. If she reaches the prescribed level in 2 weeks and a month later found to have 21.5% body fat, she would be released from the program. If the cadet is administered another percent body fat measurement in February as a result of a weight gain shown in a routine class height/weight survey, and found to be 24% body fat, she could be recommended for dismissal.

ADMINISTRATIVE DISMISSAL:

Administrative dismissal under the Weight Control Program will be processed in accordance with Regulations for the United States Military Academy, paragraph 12.04 (proposed para 10.08, Revised Regs USMA .

LIST OF TABLES

APPENDIX B

Table 1. Distribution of Subjects from USCC

		Class (of)[1]					
Phase	Subjects	1979	1980	1981	1982	1983	Total
Phase I	Female	...	27	17	25	...	69
	Male	26	39	48	49	...	162
	Total	26	66	65	74	...	231
Phase II	Female	...	14	14	6	8	42
	Male	...	26	24	33	11	94
	Total	...	40	38	39	19	136
Phase I and II	Female	...	13	4	4	...	21
	Male	...	12	13	12	...	37
	Total	...	25	17	16	...	58

[1]There were no females in the class of 1979 and the class of 1983 did not participate in phase I.

Table 2. Weight and Height Data from Phase I

Parameter	Sex	First-79	Second-80	Third-81	Fourth-82	Significant Difference (Sex Effect)
		Class[1]				
Weight (kg)	F	...	61.16 ± 7.90	58.95 ± 5.76	59.30 ± 6.13	
	M	76.32 ± 10.32	76.96 ± 10.49	77.55 ± 9.78	73.93 ± 6.24	$p < .001$
Height (cm)	F	...	167.52 ± 6.57	165.05 ± 7.29	166.48 ± 7.47	$p < .001$
	M	180.73 ± 8.44	178.86 ± 6.64	178.55 ± 6.00	177.38 ± 6.04	

[1] The values represent mean $\pm$ standard deviation. No significant differences among classes and no significant interactions between class and sex were identified for height or weight.

Table 3. Skinfold Data from Phase I

Parameter	Sex	Class[1] First-79	Second-80	Third-81	Fourth-82	Significant Difference (Sex Effect)
TCR	F	...	13.44±3.37	14.24±3.45	14.22±2.96	p<.001
(mm)	M	7.78±2.91	7.96±2.65	7.88±2.91	8.47±2.71	
TCL	F	...	13.06±3.34	14.41±3.51	14.72±3.08	p<.001
(mm)	M	7.48±2.93	7.61±2.58	7.85±3.07	8.05±2.46	
SSR	F	...	10.72±3.56	10.56±1.68	10.36±2.46	NSD
(mm)	M	9.98±2.95	10.54±2.70	10.92±3.12	9.97±2.43	
SSL	F	...	10.65±3.29	10.59±1.73	10.22±2.81	NSD
(mm)	M	9.67±2.56	10.21±2.50	10.27±2.94	9.82±2.33	
BCR	F	...	5.91±2.52	5.53±1.43	6.00±2.23	p<.001
(mm)	M	3.90±1.20	3.73±1.20	3.96±1.22	3.90±1.04	
BCL	F	...	6.07±2.51	5.76±1.68	6.06±2.02	p<.001
(mm)	M	4.13±1.26	4.20±1.52	4.31±1.34	4.19±1.18	
SIR	F	...	12.33±5.13	12.35±3.18	11.32±3.91	NSD
(mm)	M	13.54±5.68	13.54±5.10	13.33±5.03	12.03±4.19	
SIL	F	...	12.57±5.78	12.76±3.61	11.72±3.50	NSD
(mm)	M	13.38±5.10	13.07±4+94	13.09±5.11	12.20±3.49	

Table 3. (continued)

Parameter	Sex	Class: First-79	Second-80	Third-81	Fourth-82	Significant Difference (Sex Effect)
LAR	F	...	8.17±3.88	7.76±1.95	7.88±3.06	p<.005
(mm)	M	6.73±2.87	6.70±2.68	6.95±2.87	6.56±2.06	
LAL	F	...	8.00±3.81	7.91±2.24	7.40±2.75	NSD
(mm)	M	6.79±3.30	7.17±3.11	7.23±2.97	6.55±2.34	
ABR	F	...	11.31±4.76	12.74±3.44	10.74±3.78	p<.001
(mm)	M	9.77±4.05	9.33±3.87	9.70±4.06	8.70±2.94	
ABL	F	...	11.61±5.12	13.20±3.70	11.20±3.49	p<.001
(mm)	M	9.04±4.00	8.91±4.05	9.21±3.88	8.36±3.00	
THR	F	...	21.98±5.65	22.53±4.47	23.06±3.94	p<.001
(mm)	M	10.40±3.43	11.58±5.04	11.28±3.94	11.47±4.18	
THL	F	...	22.06±5.18	22.88±4.30	23.00±3.95	p<.001
(mm)	M	10.92±3.23	11.99±5.28	11.81±4.07	12.03±4.04	

[1]The values represent mean ± standard deviation
[2]NSD means $p > 0.05$. No significant differences among classes and no significant interaction between class and sex were indentified for any skinfold parameter.

Table 4. Circumference Data from Phase I

Parameter	Sex	Class[1] First-79	Second-80	Third-81	Fourth-82	Significant Difference[2] (Sex Effect)
NK	F	...	31.92 ± 1.55	31.33 ± 1.74	31.73 ± 1.52	$p < .001$
(cm)	M	37.70 ± 1.75	37.88 ± 2.17	38.00 ± 2.21	37.77 ± 1.69	
SH	F	...	100.62 ± 5.03	98.90 ± 4.22	99.55 ± 3.71	$p < .001$
(cm)	M	112.93 ± 6.9	113.67 ± 6.09	114.48 ± 6.57	112.53 ± 4.37	
CH	F	...	74.71 ± 4.38	72.84 ± 4.83	73.20 ± 2.84	$p < .001$
(cm)	M	89.43 ± 7.10	90.25 ± 6.18	91.13 ± 6.40	88.43 ± 5.17	
AB	F	...	69.56 ± 6.06	69.45 ± 6.09	68.79 ± 5.42	$p < .011$
(cm)	M	78.89 ± 5.83	79.73 ± 5.08	79.82 ± 6.02	78.44 ± 4.94	
BU	F	...	95.79 ± 5.28	95.02 ± 4.18	93.78 ± 4.34	$p < .014$
(cm)	M	96.99 ± 6.49	96.92 ± 5.09	97.69 ± 5.73	95.42 ± 4.07	
TR	F	...	56.59 ± 3.45	56.55 ± 3.04	55.95 ± 3.16	NSD
(cm)	M	57.44 ± 4.14	57.58 ± 4.34	58.01 ± 5.35	57.00 ± 2.92	
TL	F	...	56.21 ± 3.58	56.44 ± 2.63	55.53 ± 3.26	$p < .038$
(cm)	M	36.91 ± 4.14	57.43 ± 4.40	57.90 ± 5.30	56.60 ± 2.88	

[1]The values represent mean $\pm$ standard deviation.
[2]NSD means $p > .05$. No significant differences among classes and no significant interactions between class and sex were identified for any of the parameters measured.

Table 5. Percent Body Fat Data from Phase I

		Class [1]				
Parameter	Sex	First-79	Second-80	Third-81	Fourth-82	Significant Difference[2] (Sex Effect)
PFBV	F	...	27.51±5.63	24.61±5.42	23.55±5.61	NSD
(%)	M	18.30±5.35	18.02±5.58	17.20±5.25	18.98±6.58	
PFWD	F	...	23.92±4.20	24.52±2.47	23.61±3.36	$p<.001$
(%)	M	14.07±3.50	14.38±3.27	14.39±3.33	14.45±2.84	
PFWP	F	...	22.44±3.98	22.90±2.35	22.33±3.26	$p<.001$
(%)	M	11.60±3.20	11.94±3.16	12.18±3.18	12.31±2.72	

[1]The values represent mean ± standard deviation.

[2]NSD means $p > .05$. No significant differences among classes and no significant interactions between class and sex were identified for any body fat measurement.

Table 6. Comparison of Investigator Differences

Measurement	Sex	Investigator	Class[1] First-79	Second-80	Third-81	Fourth-82	Significant Difference[2] Sex	Investigator
Triceps	F	LAIR	...	12.73±2.75	12.90±3.33	14.73±2.94	p<.001	NSD
		USMA	...	12.03±3.10	13.65±2.69	14.53±2.94		
	M	LAIR	7.64±3.26	7.40±1.98	7.70±2.75	7.94±2.16		
		USMA	7.47±3.59	7.36±2.09	8.48±3.10	7.76±1.98		
Subscapular	F	LAIR	...	10.85±3.20	10.48±1.24	10.84±3.02	NSD	p< .001
		USMA	...	10.24±3.73	8.70±1.96	10.15±3.32		
	M	LAIR	9.84±2.61	10.11±2.05	10.50±2.95	10.23±1.93		
		USMA	9.42±2.67	9.64±2.18	9.80±2.38	9.46±2.26		
Biceps	F	LAIR	...	6.22±2.70	5.22±1.53	6.72±2.16	p<.001	NSD
		USMA	...	6.09±2.40	5.60±1.60	6.34±2.04		
	M	LAIR	4.25±1.28	3.71±0.66	4.11±1.12	4.06±1.08		
		USMA	4.24±1.35	3.69±0.49	4.04±1.04	4.05±1.13		
Lateral abdominal	F	LAIR	...	7.87±3.93	7.38±1.52	8.42±3.20	p<.003	p<.038
		USMA	...	8.23±3.84	8.90±2.70	8.62±2.96		
	M	LAIR	6.89±3.30	6.53±1.65	6.76±2.20	7.05±2.47		
		USMA	7.03±3.16	6.50±1.86	6.44±1.80	7.02±2.50		
Percent Fat	F	LAIR	...	22.33±4.00	21.96±2.42	23.16±3.46	p<.001	p<.003
		USMA	...	21.48±3.83	21.97±2.23	22.71±3.58		
	M	LAIR	11.71±3.43	11.62±2.02	12.03±2.84	12.40±2.65		
		USMA	11.54±3.49	11.43±2.34	11.94±2.76	11.76±2.49		

[1]The values represent mean ± standard deviation.
[2]NSD means p>0.05.

Table 7. Weight and Height Data from Phase II

Parameter	Sex	Class[1] First-80	Second-81	Third-82	Fourth-83	Significant Difference[2] (Sex Effect)
Weight (kg)	F	60.88 ± 8.42	60.75 ± 7.45	59.06 ± 6.45	62.97 ± 6.46	$p < .001$
	M	77.60 ± 10.90	74.01 ± 8.80	75.88 ± 7.92	79.70 ± 8.55	
Height (cm)	F	165.37 ± 4.68	165.88 ± 7.11	164.85 ± 6.73	164.92 ± 4.56	$p < .001$
	M	178.74 ± 6.07	175.19 ± 6.47	176.53 ± 7.72	179.81 ± 7.66	

[1]The values represent mean $\pm$ standard deviation.
[2]No significant differences among classes and no significant interactions between class and sex were identified for weight or height.

Table 8. Skinfold Data from Phase II

Parameter	Sex	Class[1] First-80	Second-81	Third-82	Fourth-83	Significant Difference[2] (Sex Effect)
TCR	F	12.75±4.48	12.14±3.00	13.25±2.42	13.81±2.67	p<.001
(mm)	M	8.19±2.99	7.62±2.17	7.58±2.00	9.14±2.30	
TCL	F	13.07±4.23	12.64±3.48	14.33±3.34	14.56±2.50	p<.001
(mm)	M	8.13±2.84	7.79±2.44	7.56±2.00	9.14±2.55	
SSR	F	10.32±3.55	9.36±2.53	8.58±1.56	10.88±3.17	NSD
(mm)	M	10.17±2.88	10.12±2.41	10.21±2.24	9.50±2.06	
SSL	F	10.07±3.00	9.25±2.22	8.83±1.37	10.81±3.32	NSD
(mm)	M	10.21±2.61	10.10±2.08	10.14±2.27	9.09±2.31	
BCR	F	6.25±3.02	5.07±1.72	6.42±1.28	5.88±1.94	p<.001
(mm)	M	3.96±1.26	4.06±1.34	3.78±0.82	4.13±0.78	
BCL	F	6.14±3.16	5.21±1.89	6.08±1.43	6.00±1.79	p<.001
(mm)	M	4.52±1.63	4.02±1.16	3.83±0.80	4.32±0.98	
SIR	F	12.11±5.81	10.68±3.66	10.83±1.72	13.56±4.58	p<.036
(mm)	M	13.98±6.56	12.64±3.28	13.44±4.52	15.32±4.72	
SIL	F	11.89±6.06	10.93±3.69	11.00±1.26	12.62±3.96	p<.029
(mm)	M	14.31±6.20	12.48±3.47	13.32±4.41	14.68±4.67	

Table 8. (continued)

Parameter	Sex	Class: First-79	Second-80	Third-81	Fourth-82	Significant Difference (Sex Effect)
LAR	F	8.32±4.70	7.36±2.44	6.17±0.98	7.69±2.34	NSD
(mm)	M	7.83±3.83	7.21±2.84	6.89±2.25	7.23±1.40	
LAL	F	8.14±4.63	7.07±2.06	6.33±0.82	7.38±2.13	NSD
(mm)		7.58±3.80	7.02±2.70	6.62±2.14	7.18±1.54	
ABR	F	11.46±5.92	9.43±3.71	8.08±2.41	10.19±5.11	NSD
(mm)	M	10.00±4.61	9.50±3.16	8.24±3.03	8.86±1.87	
ABL	F	11.46±6.21	9.57±3.20	8.25±2.32	10.69±4.53	NSD
(mm)		9.58±4.61	9.08±3.48	7.97±3.02	8.32±1.74	
THR	F	21.07±6.53	18.61±4.28	21.67±3.67	21.38±5.29	p<.001
(mm)	M	11.03±4.56	9.83±3.36	10.39±2.32	10.27±2.95	
THL	F	20.93±6.59	18.21±4.78	21.42±3.20	20.38±5.37	p<.001
(mm)	M	11.44±4.51	10.42±3.04	10.73±2.40	10.32±2.86	

[1]The values represent mean ± standard deviation.
[2]No significant class effect and no significant interaction between class and sex were identified for any parameter.

Table 9. Percent Body Fat from Phase II

		Class[1]				
Parameter	Sex	First-80	Second-81	Third-82	Fourth-83	Significant Difference (Sex Effect)
PFWD (%)	F	23.41±4.78	22.51±3.07	23.50±1.35	24.64±3.85	$p<.001$
	M	14.56±3.93	14.12±2.48	14.29±2.58	15.21±2.57	
PFWP (%)	F	22.04±4.77	21.11±3.01	21.69±1.88	22.88±3.42	$p<.001$
	M	12.34±3.60	12.03±2.64	11.86±2.18	12.53±1.99	

[1]The vlaues represent mean ± standard deviation.

Table 10. Oxygen Uptake Data from Phase II

Parameter	Sex	Class[1] First-80	Second-81	Third-82	Fourth-83	Significant Difference (Sex Effect)
V_{O_2max} (ml)	F	2473±656	2536±629	2534± 315	2643±369	p<.001
	M	3909±739	3502±626	3873±1008	4139±762	
V_{O_2max} (ml/kg)	F	40.49±8.83	41.94±9.89	42.91± 2.59	42.32±7.52	p<.002
	M	50.63±8.59	47.53±7.50	51.30±13.24	51.77±6.33	

[1] The values represent mean ± standard deviation.

Table 11. Weight and Height Data from Subjects Completing both Phases I and II

Parameter	Sex	Phase	Class[1] First-80	Class[1] Second-81	Class[1] Third-82	Significant Difference (Sex Effect)	Significant Difference (Phase Effect)
Weight (kg)	F	I	58.56±6.61	60.18±5.32	55.19±3.09	$p<.001$	$p<.002$
	F	II	59.94±8.08	62.41±5.62	55.34±2.88		
Weight (kg)	M	I	77.80±11.90	73.35±6.35	71.01±5.66		
	M	II	78.64±12.37	75.00±7.56	72.12±5.61		
Height (cm)	F	I	165.82±6.26	166.20±6.92	164.10±3.04	$p<.001$	NSD
	F	II	165.75±4.57	164.42±7.74	163.68±3.38		
Height (cm)	M	I	179.34±7.94	175.49±6.17	174.99±4.06		
	M	II	179.08±7.83	175.28±6.22	175.11±4.55		

[1]The values represent mean ± standard deviation.

Table 12. Skinfold Data from Subjects Completing both Phases I and II

Parameter	Sex	Phase	Class[1] First-80	Class[1] Second-81	Class[1] Third-82	Significant Difference[2] (Sex Effect)	Significant Difference[3,4,5] (Phase Effect)
TCR	F	I	13.62±3.04	13.87±2.87	12.38±2.40	p<.001	NSD
(mm)	F	II	13.50±4.54	13.50±3.00	11.62±2.56		
	M	I	7.86±2.56	8.27±3.65	8.62±2.58		
	M	II	7.42±3.19	7.96±3.08	7.79±1.79		
TCL	F	I	13.08±2.78	13.88±3.06	13.00±2.34	p<.001	NSD
(mm)	F	II	13.77±4.17	14.75±4.11	12.25±2.02		
	M	I	7.58±2.71	8.46±3.90	8.08±2.85		
	M	II	7.50±2.93	7.92±3.49	7.79±1.97		
SSR	F	I	10.08±3.16	12.12±2.25	8.87±1.75	NSD	p<.021
(mm)	F	II	9.85±3.07	12.00±3.16	8.00±1.63		
	M	I	10.05±2.49	10.92±3.52	10.00±2.47		
	M	II	10.08±2.46	10.15±3.29	9.71±1.75		
SSL	F	I	10.00±2.86	12.00±2.45	8.00±1.41	NSD	NSD
(mm)	F	II	9.69±2.76	11.50±2.65	8.75±1.50		
	M	I	10.45±2.04	10.19±2.83	9.79±2.07		
	M	II	10.08±2.24	9.88±2.39	9.41±1.58		

Table 12. (continued)

Parameter	Sex	Phase	Class First-79	Class Second-80	Class Third-81	Significant Difference (Sex Effect)	Significant Difference (Phase Effect)
BCR	F	I	5.69±2.49	5.50±0.91	5.25±1.19	P<.001	NSD
(mm)	F	II	6.19±3.05	6.00±1.82	5.38±1.49		
	M	I	3.83±1.23	4.00±1.11	3.92±1.00		
	M	II	3.62±0.77	3.92±1.35	3.46±0.66		
BCL	F	II	6.04±2.52	5.62±1.25	5.00±0.82	p<.005	NSD
(mm)	F	II	6.15±3.06	6.38±2.56	5.12±1.31		
	M	I	4.25±1.64	4.35±1.33	4.12±1.17		
	M	II	4.41±1.58	3.96±1.09	3.79±0.83		
SIR	F	I	11.50±4.06	12.12±1.31	9.12±1.75	NSD	NSD
(mm)	F	II	11.50±5.38	11.00±3.46	10.00±3.46		
	M	I	13.83±5.02	12.08±5.78	11.46±3.92		
	M	II	14.25±7.05	13.11±6.00	13.42±3.99		
SIL	F	I	11.69±4.18	14.00±2.16	9.62±2.93	NSD	NSD
(mm)	F	II	11.42±5.33	12.75±2.63	10.50±2.64		
	M	I	14.74±5.56	12.04±5.70	11.79±3.42		
	M	II	14.12±6.02	12.69±5.51	12.38±3.49		

Table 12. (continued)

Parameter	Sex	Phase	Class: First-79	Class: Second-80	Class: Third-81	Significant Difference (Sex Effect)	Significant Difference (Phase Effect)
LAR	F	I	7.42±3.78	8.50±1.73	6.12±0.85	NSD	NSD
(mm)	F	II	7.85±4.62	8.25±2.63	5.38±1.11		
	M	I	7.00±2.70	6.77±4.09	6.17±1.42		
	M	II	8.25±4.59	7.38±5.20	6.42±1.55		
LAL	F	I	7.23±2.72	8.88±2.59	5.75±0.50	NSD	NSD
(mm)	F	II	7.61±4.26	7.75±2.22	5.50±1.29		
	M	I	7.62±3.34	7.23±4.22	6.21±1.70		
	M	II	7.54±3.89	7.50±5.41	6.38±1.72		
ABR	F	I	10.19±3.58	15.62±1.38	7.87±0.85	P<.031	p<.017
(mm)	F	II	10.73±5.64	11.50±3.87	6.37±2.43		
	M	I	10.04±3.65	10.19±4.96	7.71±2.24		
	M	II	9.91±4.84	9.42±5.03	8.00±2.45		
ABL	F	I	10.46±3.83	15.87±2.10	8.50±1.29	p<.045	p<.005
(mm)	F	II	10.69±5.60	11.50±2.51	6.62±2.50		
	M	I	9.75±3.84	9.69±5.14	7.29±2.05		
	M	II	9.45±4.85	9.04±5.37	7.41±2.14		

Table 12. (continued)

Parameter	Sex	Phase	Class First-79	Class Second-80	Class Third-81	Significant Difference (Sex Effect)	Significant Difference (Phase Effect)
THR	F	I	21.58±5.73	20.50±2.08	20.25±3.40	p<.001	p<.001
(mm)	F	II	21.31±6.73	20.25±3.68	18.00±4.69		
	M	I	11.67±4.22	10.65±4.34	10.29±2.11		
	M	II	10.12±4.34	10.30±4.08	9.29±1.79		
TAL	F	I	21.54±5.59	20.62±1.89	21.12±3.42	p<.001	p<.024
(mm)	F	II	20.61±6.75	19.75±3.30	18.62±3.90		
	M	I	11.88±3.59	11.96±4.00	11.62±2.93		
	M	II	10.62±4.24	10.69±4.04	10.16±1.80		

1The values represent mean ± standard deviation.
2The phase by sex interaction (males increased and females decreased) was significant (p<.034).
3All interactions significant due to high values for sophomore females in phase I (phase by class: p<.022, phase by sex: p<.025, phase by class and by sex: p<.047).
4The phase by class interaction was significant (p<.016) due to high value for sophomore females in Phase I.
5NSD means p>.05.

Table 13. Percent Fat Estimates from Subjects Completing both Phases I and II

Estimate	Sex	Phase	Class[1] First-80	Class[1] Second-81	Class[1] Third-82	Significant Difference (Sex Effect)
PFWP	F	I	21.56±3.25	23.06±2.03	20.16±1.57	p<.001
		II	21.57±4.19	22.83±3.27	19.64±1.86	
	M	I	12.05±3.23	12.51±3.83	12.20±2.65	
		II	12.36±3.62	12.17±3.89	11.81±2.21	
PFWD	F	I	22.03±3.26	24.48±1.61	21.46±1.96	p<.001
		II	22.88±4.13	24.07±3.27	21.50±2.29	
	M	I	15.00±3.33	14.39±3.76	14.25±2.74	
		II	14.60±3.92	14.33±3.53	14.29±2.55	

[1]The values represent mean ± standard deviation.

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